Party-line Telephone Systems with a Novel Selective Ringing Feature

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SUMMARY

The article opens with a brief discussion of the importance of these systems in railway telecommunications and their development for use on electrified railways. Reference to the two main types of party-line systems is followed by an outline of the general requirements and operation of the 'Control Only' system. The 'Inter-waystation Calling' system and the construction of the waystation telephone unit are then described. The author indicates further industrial applications and closes with a description of the galvanometer relay and pulse generator

Waystation telephone in use at Edge Hill, Liverpool

PARTY-LINE TELEPHONE SYSTEMS will continue for some decades to be a principal requirement of railway telecommunications in many parts of the world. These systems are an economic necessity since the telephone points of the railway administration, such as stations and signal boxes, are strung out alongside the railway tracks, and the cost of wiring each telephone 10, 50 or 100 miles back to the central switching office would be prohibitive. There are, of course, other advantages in such systems for railway use, one particular example being that from any telephone point one can cut into an existing call on the line in an emergency.

The party-line circuits used for connecting signal boxes and other traffic reporting points to the associated traffic control are considered to be the most important telecommunication circuits in railway service since they are a direct link in the control of train movements. On electrified railway systems these lines are also employed extensively for the exchange of messages between strategically spaced track-side telephones and the parent traction control office; such messages could be for the purpose of effecting isolation of a section of the traction supply for maintenance work or during an emergency. In addition to the track-side circuits, many party lines also cater for the commercial activities of the railway system, serving such places as station offices, parcel and freight terminals, and marshalling yards.

A large number of these circuits at present employ code-ring signals where all the telephone bells on a circuit ring for each call, and each party has to listen in case it is his code. When the traffic on a party line is heavy the frequent ringing of bells at each telephone becomes extremely disturbing, particularly in a large office with several different circuits. It is desirable, therefore, to use a system where a telephone bell rings only when that particular party is required; such a telephone system is known as a Selective Ringing Party Line.

It is estimated that there are over 100 000 party-line telephones in the service of British Railways and this gives some indication of the importance of this type of circuit. Most of the telephones are, as yet, on non-selective circuits but progress is being made in the provision of selective ringing.

A telephone switchboard in use in Sandbach Signal Box

ELECTRIFIED RAILWAYS

The decision to electrify British Railways with an overhead traction power supply of 25 000 volts 50 c/s single phase, introduced the problem of induction from the traction system into the track-side telecommunication circuits. The continued employment of aerial routes for telephone circuits was impracticable because of the induced voltages. Apart from the resultant noisy conditions on the speech circuits, during traction faults the induced voltages could be dangerous to telephone users.

The first requirement of any telecommunication network in an area electrified with such high traction voltages is to eliminate all overhead wires and to replace them by specially screened cable. The C.C.I.T.T. recommendation of maximum longitudinal induced voltages of 60 volts r.m.s. under normal working conditions, and 430 volts r.m.s. under fault conditions of traction feeds, was accepted by the British Railways. This necessitated, in addition to cable screening, the use of line sectionalising transformers in every pair of the track-side telephone cables. With the type of screened cable and traction system adopted, it was calculated that, to meet the specified limits, sectionalising transformers should be inserted in all lines exceeding approximately 15 miles.

The decision to use sectionalising transformers had a profound effect on the telecommunication systems of the British Railways, since normal d.c. signalling was no longer permissible on such lines.

Since most of the traffic control circuits extend for distances greater than 15 miles, existing party-line systems employing d.c. signalling were obviously unsuitable. It was to meet this situation that the A.T.E. Selective Party-line Telephone System, utilising a.c. signalling, was developed. The A.T.E. system has been approved by British Railways and a number of installations are now in service, in non-electrified as well as electrified areas.

TYPES OF PARTY LINE

British Railways party lines are divided into two main groups: (*a*) Control Only and (*b*) Inter-waystation Calling.

With 'Control Only', the Control Office can make a selective call to a party-line telephone, known as a 'waystation', but the waystation can only call the Control Office; however, the Controller can extend the waystation call to any other party line, or to another waystation on the same line.

'Inter-waystation Calling' permits direct calling between parties.

THE A.T.E. 'CONTROL ONLY' SELECTIVE SYSTEM

General Requirements

The requirements of a Control Only party-line system for high-voltage electrified areas are as follows:

—To allow a large number of telephones or waystations to be connected to one pair of wires.

—To be capable of signalling over cable (in electrified areas) and/or overhead wire (in non-electrified areas).

—To function over lines with sectionalising transformers or loading coils.

—Signalling equipment at each waystation to present a high shunt-impedance to speech to reduce losses in a long line.

—The system to operate and bells to ring, even when a number of telephone handsets, including that of the called waystation, are removed from the handset rest.

—The power requirements at the waystation to be met by two small dry cells (3 volts).

—The whole system to be free from earth potential connections.

—The system to function satisfactorily with induced longitudinal voltages of up to 60 volts r.m.s. normally or 430 volts r.m.s. under fault conditions.

—To permit any waystation to interrupt an established call.

—Simple waystation or Control Office calling procedure, with ring-back tone indication from the called end that the bell is ringing.

—The Control Office to be able to call pre-determined groups of waystations simultaneously, for the transmission of general information.

—The waystation bell to ring for a period of approximately 4 seconds, with operation of a loud-sounding bell if required.

—The Control Office to be able to inter-connect circuits as required, with an operator recall facility available on these circuits.

—The equipment to be compact and simple to install and maintain.

—Any waystation to be capable of acting as a remotely controlled coupling unit to provide temporary connection facilities to another remote party line as required.

The A.T.E. System was developed to fulfil these requirements and some 3 500 waystation telephones, installed progressively since 1958, are giving reliable service on British Railways.

System Operation

The basic elements of the system are shown in Figure 1 and the operation of the system is described in more detail below.

Control Office to Waystation Call

The Control Officer seizes the required party line by operating the associated keyswitch on a keyboard, or by plugging into a jack on a plugboard, and ascertains by listening whether or not the line is already in use.

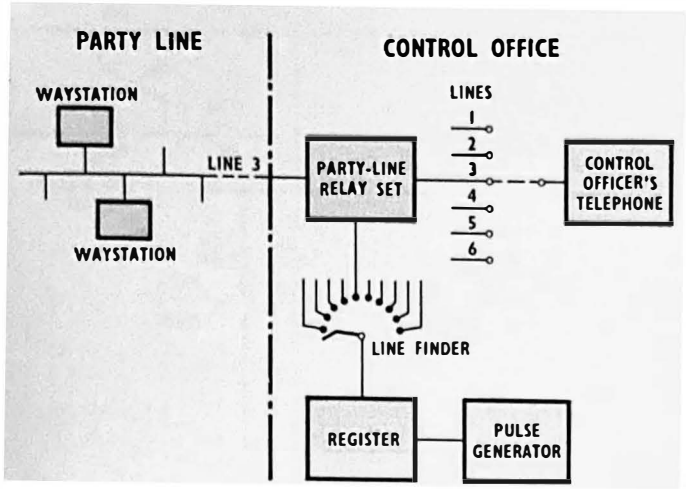


Figure 1. 'Control Only' scheme. Basic circuit

The line finder automatically connects a register and pulse generator to the party-line relay set and the waystation required is then selected by the Control Officer dialling a two-digit number. The register receives the dialled digits and causes the pulse generator to send pulses of 50 c/s current at a rhythmic rate to the party line, via the register and the party-line relay set.

Although the pulsed signal is fed to all waystations on that line, it will only be effective in triggering the ringing circuit at one particular waystation. The selective device at each waystation is an A.T.E. galvanometer relay, of which over a million have been used for various selective control purposes since its inception in 1939.

The principle of the galvanometer relay, which is described more fully in the Appendix, is that of a pivoted permanent-magnet assembly which is arranged to have a specific periodicity of swing under the control of a spiral spring. If the surrounding coil receives pulses of current at this periodicity, the magnet assembly will be caused to build up in oscillation until a contact on the magnet assembly touches a fixed contact on the frame. The operation of these contacts triggers the waystation ringing circuit.

The galvanometer relay can be adjusted to any one of 24 different oscillation rates, thus catering for 24 waystation selections. The oscillation rates vary from 1 per second to about 11 per second and the operating pulses are sent at these rates with a 50/50 on/off ratio. A relay will operate in about three to four seconds and will make several swing contacts during the signal transmission. The relays at non-selected waystations will attempt to swing but will be damped down by the out-of-rhythm pulses.

Reverting to the operation of the waystation circuit (Figure 2), the galvanometer relay GA is connected across the line in series with a rectifier and a cold cathode tube T. The rectifier ensures the passage of the uni-directional current required by the magnet-deflecting galvanometer coil, while the cold cathode tube presents a high shunt-impedance circuit to low voltages, such as during speech.

The signal current frequency was chosen at 50 c/s so that the mains supply could be used as the frequency source. This current is amplitude modulated at the

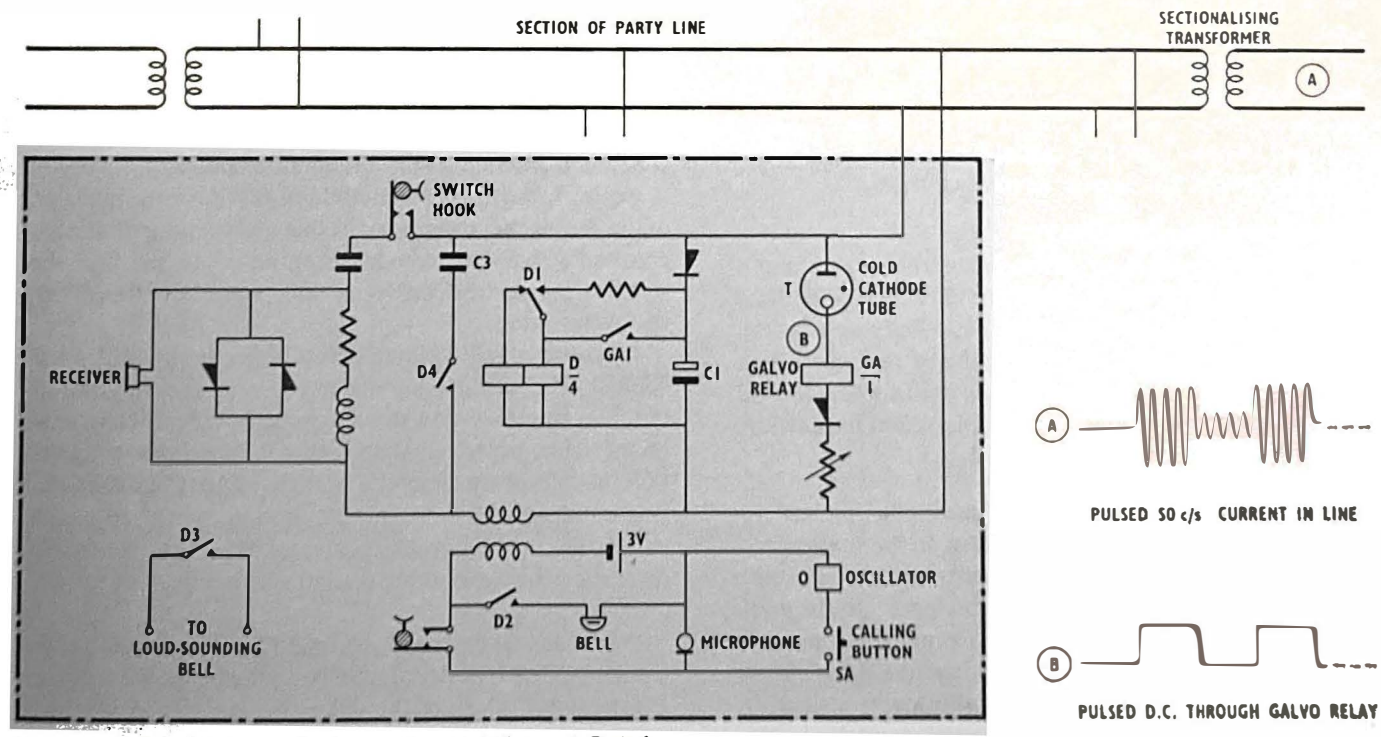


Figure 2. Waystation telephone circuit, 'Control Only'

Control Office by the rhythm to be signalled, in a 50% high, 50% low voltage sequence. The voltages are 100V r.m.s. (or higher) and 40V r.m.s. respectively.

At the waystation, the cold cathode tube strikes at about 50V r.m.s., therefore only accepts the high voltage pulses. If the galvo relay adjustment coincides with the pulsed signal rhythm, the relay will build up in oscillation and operate its contacts GA1.

Apart from energising the galvo relay, the pulsed signal current charges capacitor C1 and when galvo contacts GA1 close, relay D will operate to the discharge and will hold for the duration of the pulsing, via contacts D1. Contacts D2 complete the bell circuit and when the bell rings, ring-back tone is induced into the line via the induction coil, contacts D4, and capacitor C3.

The galvo relay contacts GA1 close after about 4 seconds but the signal is transmitted for about 6 seconds. By reason of relay D holding to capacitor C1, the bell circuit is maintained for a total of about 4 seconds. At the Control Office, when the signal cycle is completed, the line is disconnected from the pulsing-out circuit and re-connected to the operator's telephone and he hears about two seconds of the ring-back tone.

Waystation to Control Office Call

The waystation caller lifts the handset and checks if the line is free, then presses the call button SA for about a second. This button energises the transistorised oscillator O and induces a voice-frequency tone into the line; at the Control Office the tone operates a v.f. receiver which has been made voice immune by means of filters and a time-delay arrangement. When the receiver operates, the waystation caller hears an interrupted ring-back tone, which is disconnected when the Control Officer connects his telephone to the calling line.

A waystation caller may signal for the Control Officer whether or not the line is already engaged.

Conference Call

By fitting an additional galvanometer relay at all or at a selected number of waystations on a party line, with these relays all adjusted to a common periodicity or rhythm, then the Control Office has the facility of calling all such waystations simultaneously. This is useful when general or emergency instructions have to be passed on quickly.

Portable Waystation

A portable waystation unit is available for use by working parties, and enables contact to be maintained between such parties and the Control Office from any point on a party line. The selective signal for the portable telephone is one pulse of approximately 10 seconds duration; this pulse charges a capacitor in a delay circuit with a cold cathode tube which eventually strikes to operate a relay and ring the bell. As the normal selective signal cycle is 6 seconds with 50/50 on/off ratio, giving an effective pulse period of only 3 seconds, this is insufficient to trigger the portable telephone ringing circuit. The portable unit user calls the Control Office in the normal waystation manner.

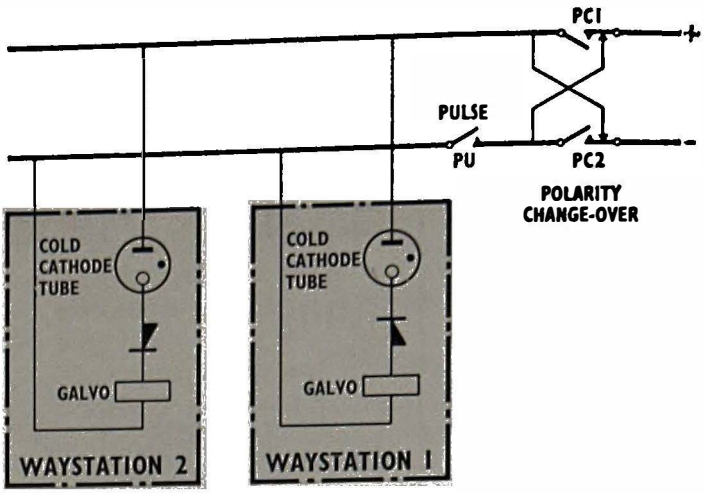


Figure 3. Waystation galvanometer circuits arranged to accept same rhythm but with signal polarity selection

The unit is designed to withstand the rough usage it is liable to receive by nature of its purpose. It is supplied in a metal case complete with a shoulder carrying strap.

D.C. Signalling where permissible

Where line conditions permit, d.c. signalling may be used, and in such systems, lower signalling voltages are permissible, the circuitry is simplified, and the number of waystations per party line may be increased to 48. The selectivity increase is achieved by using the 24 standard pulse rates and the corresponding galvanometer relays, but with the selective signal current applied with either normal or reversed direction of polarity.

Figure 3 illustrates the method of reversing the polarity of the d.c. signal currents to the line and of using similarly-adjusted galvanometer relays connected to the line via rectifiers so that selectivity is still possible between the two waystations.

When the signal voltage is rhythmically pulsed by the contact PU, the galvanometer relay at the waystation No. 1 is energised and there may be 24 different rhythms on this same polarity. When relay PC operates, contacts PC1 and PC2 reverse the signal polarity so that the galvanometer relay on the waystation No. 2 responds and again there may be connected 24 rhythms on this reversed polarity, making a total of 48 selections for the line.

When d.c. signalling is permissible, the waystation to Control Office call signal may be in the form of a loop or a potential in place of the voice-frequency tone required on a.c. signalling systems.

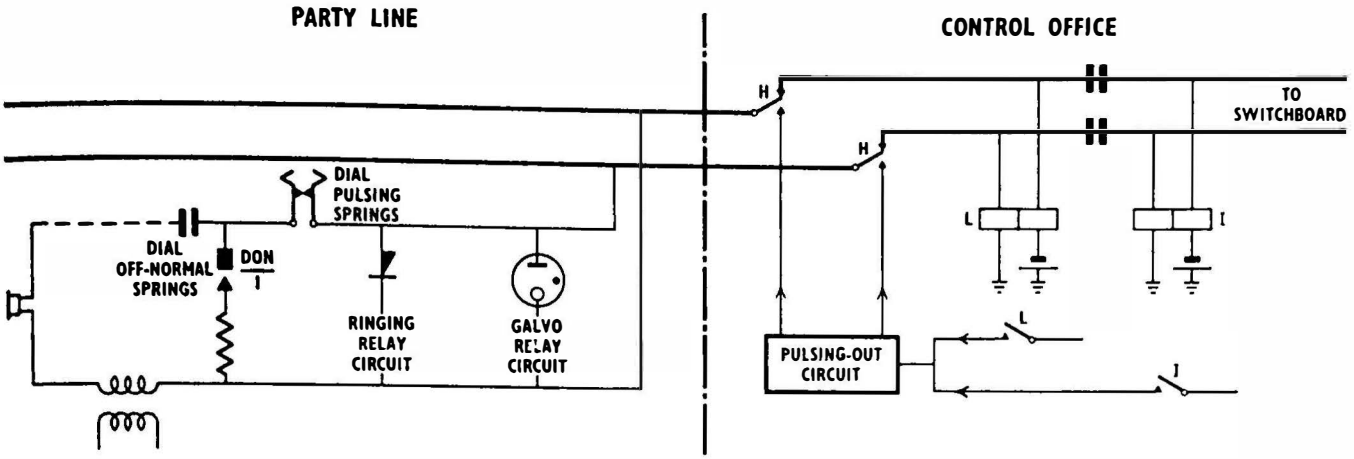


Figure 4. Waystation and Control office dialling arrangement, on d.c. lines

INTER-WAYSTATION CALLING On D.C. Signalling Lines

On Control Only circuits, the Control Office selectively calls the waystations but waystations cannot call each other except by enlisting the aid of the operator at the Control Office. A development of the basic A.T.E. system enables waystations to dial each other or the Control Office, and even to be accessible by dialling from an automatic exchange extension.

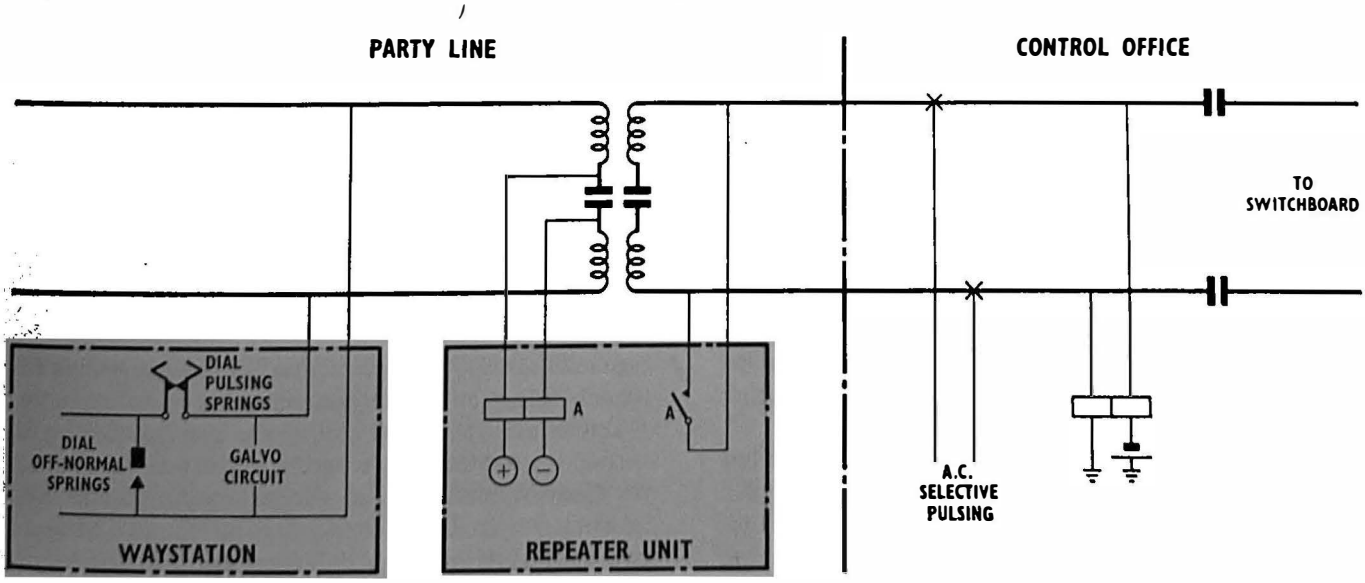
The system caters for up to 48 waystation telephones per party-line, although the usual number is about 15 as this number is considered to offer sufficient traffic to keep the circuit fully occupied.

The waystation telephone is fitted with a normal dial to send loop-disconnect pulses to the Control Office where the pulses are registered. The calling procedure follows standard telephone practice—remove handset and dial the required number—but there is no dial tone. The telephone instrument circuit is of the local battery type as this is preferable on a party-line system to provide a good level of transmission should several telephones be in use simultaneously.

If the dialled number denotes a waystation, the pulse-generator at the Control Office transmits a selective signal to the party line to call the required waystation in the manner previously described. The caller hears the selective signal being transmitted and receives ring-back tone from the called waystation bell. Referring to Figure 4, the dial off-normal contacts DON 1 close when the dial is rotated, and the L relay at the Control Office operates. When the dial is released the dial pulsing contacts pulse relay L which operates a digit-pulse counting mechanism and thus controls the selective signal pulsing-out circuit.

If the dialled number (usually a single digit) denotes the Control Office, a call signal is given at the switchboard

Figure 5. D.C. dialling on a.c. system with sectionalising transformers



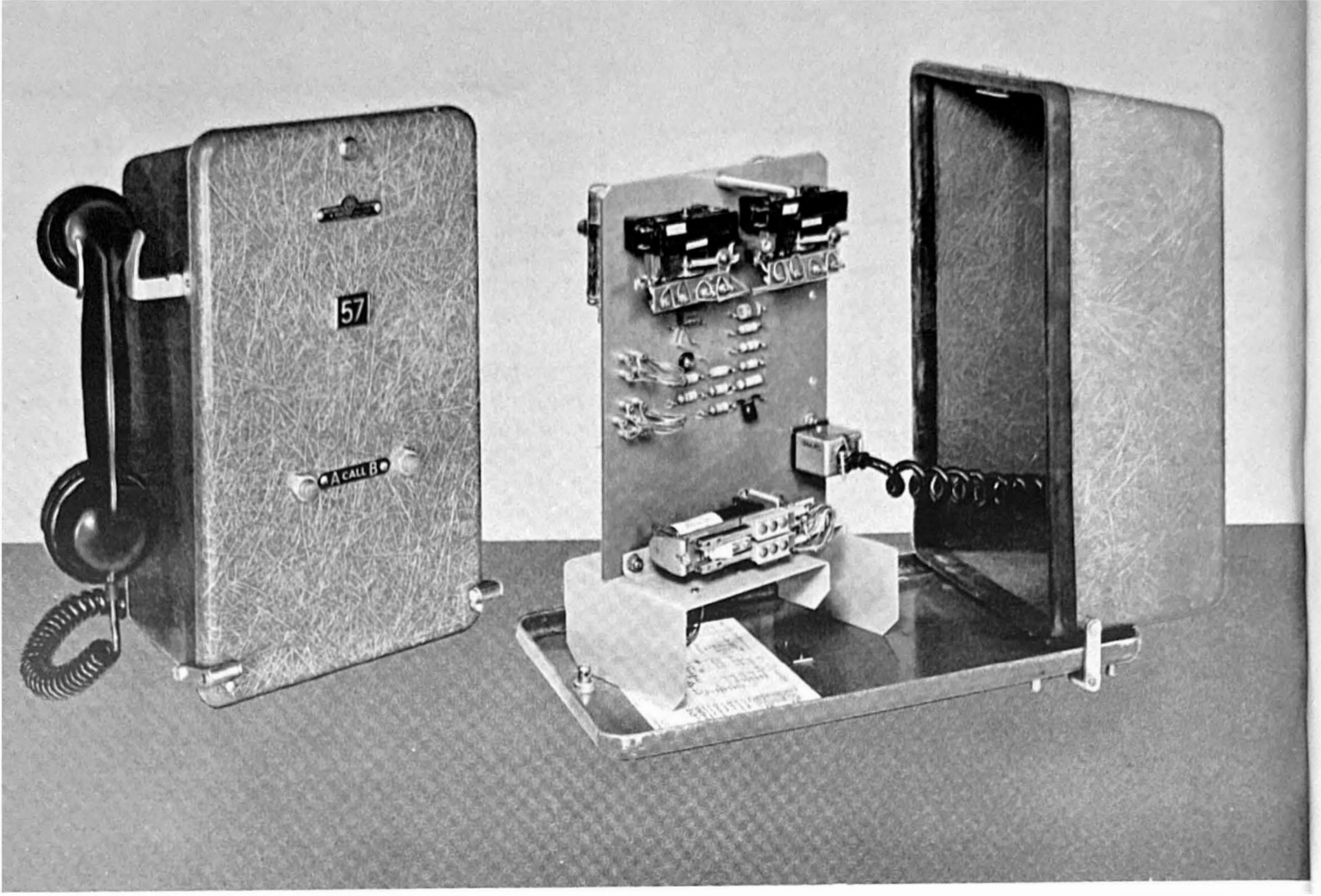


Figure 6. Waystation telephone units. *(Left) combined unit with handset and two calling buttons (Right) unit without handset and showing equipment chassis*

and the operator may receive or extend the call as required. The call may be extended on to another party line or even on to a private automatic exchange extension. Dialling at the switchboard controls the party-line pulsing-out circuit via relay I. The p.a.x. may also obtain access to a waystation by direct dialling.

As on all railway party-line systems, any party may enter the circuit and join in the conversation, or, if necessary, call in other parties by dialling, without necessitating the clearing of the line for this purpose.

On A.C. Signalling Lines

The d.c. Inter-waystation system has been adapted for use on lines fitted with sectionalised transformers, by inserting repeater units at the transformers to pass on the dialled pulses (see Figure 5) and using a.c. selective signals as on the Control Only scheme.

The power supply at the repeater unit may be of low voltage, for example, 12 or 24 volts and consist of a battery of dry Leclanché cells. The load on the repeater unit battery is very small and as it is connected for less than 2 seconds per call, the life of the battery is virtually its shelf life.

On receipt of the relayed dial pulses, the Control Office pulse generator transmits the a.c. selective signal in the normal manner.

A development proposed on this system is to employ local transistorised oscillators to transmit a.c. pulses under the control of the dial, and thus obviate the necessity of fitting dial repeater units at the sectionalising transformer points.

CONSTRUCTION OF WAYSTATION TELEPHONE UNIT

The waystation unit (Figure 6) in common use by the British Railways combines the telephone instrument and the selective unit, and is suitable for wall mounting. The case is of glass-fibre construction, as this material is extremely robust and requires no painting or maintenance. A rubber gasket is fitted around the case lip and the lid carries instruction labels and push-buttons for calling the Control Office. When released at the fastener, the lid can be lowered and it is then held by the roller brackets to act as a shelf or tray. All the equipment is mounted on

a chassis and is connected to the line terminating block by plug and socket, and an extensible cord. The unit can thus be easily and quickly removed for maintenance checks, adjustments or replacements. An extension cord with plug and socket enables the unit to be extended to a more convenient position for checking under working conditions should the telephone be inaccessible for close inspection.

Where conventional desk or wall type telephones are required, the selective unit is housed separately in the glass-fibre box which is now, of course, less handset and bell. Frequently it is necessary to install a selective waystation point as one of a number of lines on a switchboard, in which case the selective equipment would be mounted in the glass-fibre box, or it could be assembled on a conventional relay base.

APPLICATIONS FOR THE A.T.E. PARTY-LINE SYSTEMS

The systems described have all been developed specifically for the British Railways, but are obviously applicable to railway systems generally and in other cases where the telephone points are strung out over a long line. Oil pipe lines, canals, tunnels, etc. are examples of possible cases where selective ringing party lines could be used to advantage.

In addition to the telephone use, the selective feature could be used over the same lines for the remote control of switches, valves, etc. in a simple and economic manner.

APPENDIX

The Galvanometer Relay

The relay, shown in Figure 7, has an armature consisting of twin permanent bar magnets fixed on a steel spindle which is pivoted at both ends and mounted in spring-loaded jewelled bearings. The magnets are mounted in pairs to form an astatic combination which is not affected by the earth's field. The armature is held in its normal position by a spiral spring and if the armature is deflected it will have a natural periodicity of swing under the control of the spring. 24 different periodicities have been adopted and these are obtained by choice of spiral spring and magnet size. A fine adjustment to the chosen periodicity is obtained by the setting of the movable rider weights on one of the magnets. The rate of swing varies from 1 per second to about 11 per second. It is worth noting that the spacing of the periodicity values had to be very carefully plotted to avoid any one being a harmonic of another.

D.C. energisation of the relay coils will cause the magnet assembly to be deflected a few degrees. When the energisation is removed the magnets will swing back,

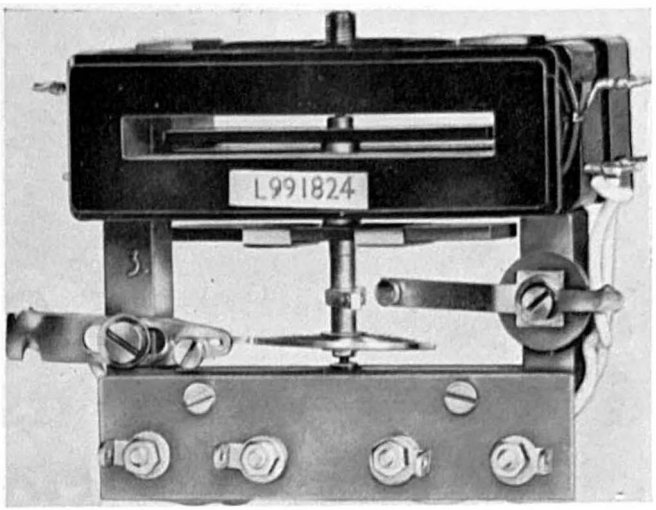


Figure 7. The galvanometer relay

then oscillate at their natural frequency. If, now, pulses of d.c. are applied to the coils and these pulses coincide with the 'rhythm' of the magnet assembly, deflection will build up until, in 2 to 4 seconds, the contact arm on the moving assembly touches a fixed contact on the relay frame; and it is this contacting that causes triggering of the selection circuit—bell, switch control, etc. Pulses out of step with the magnet rhythm will cause slight movement of the magnet assembly but would not cause a deflection sufficient for contacting.

The pulses fed to the galvanometer relay are of 50/50 on/off ratio and are maintained within close limits of the specified periodicity. The voltage level of the signal, however, is not very critical—a variation of at least 2 to 1 can be tolerated, thus allowing a large margin of voltage variation on a line. Excessive voltages could, of course, cause rhythm breakthrough but while signal voltage limiting can be provided in certain cases, on party-line circuits sufficiently close voltage control is obtained without such provision.

The relay sensitivity is 0·4V and as the coil resistance is 1 250 ohms, the power required is only 0·13mW. Despite the sensitivity of the relay, it is a simple, robust device, and with only one jewel-pivoted moving part its maintenance requirements are a minimum.

The Pulse Generator

The pulse generator consists of an assembly of 24 galvanometer relays, together with six standard telephone-relays, mounted on a jack-in base and fitted with rhythm-checking access facilities.

The circuit arrangement is such that a selected galvanometer relay interacts with the pulsing-out relay at the rhythm of the selected galvanometer relay, to send the signal pulses to the line.